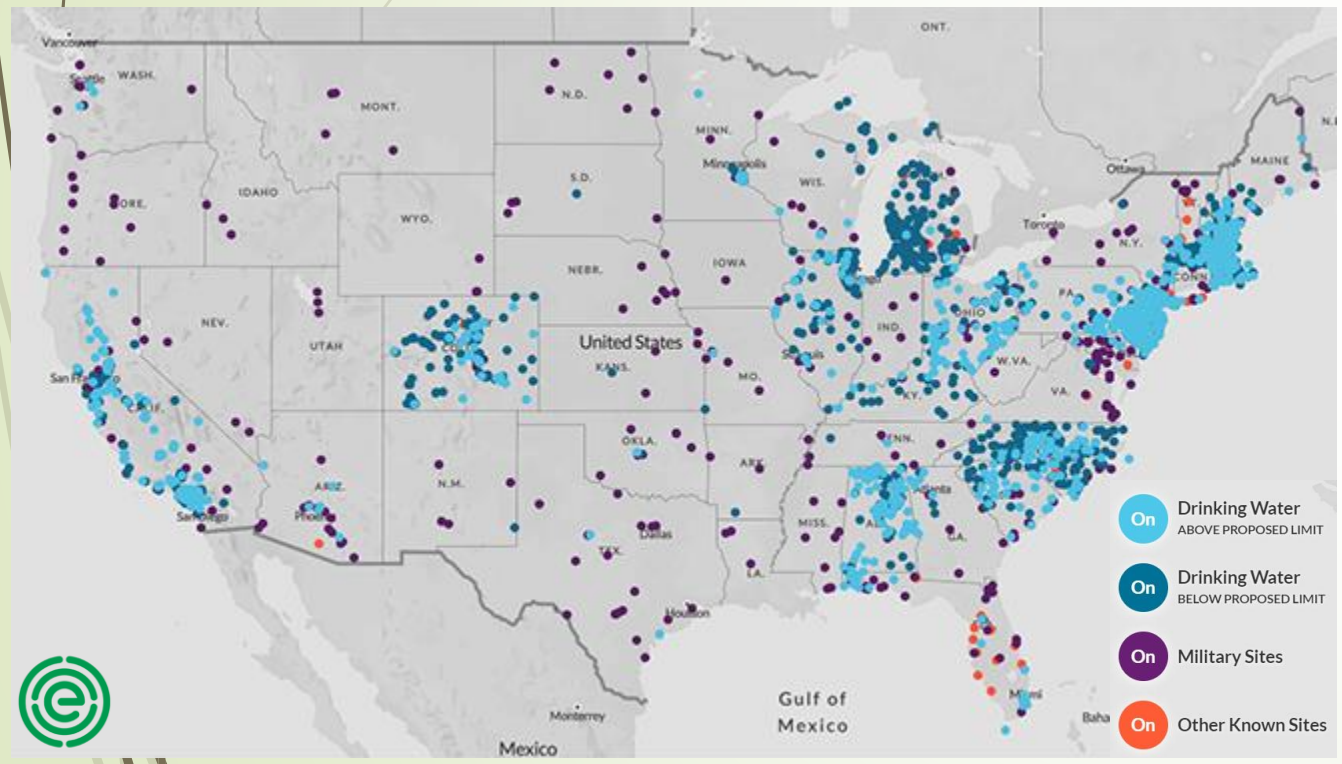
Bioaccumulation of PFAS in aquatic food webs

Matt Farrell

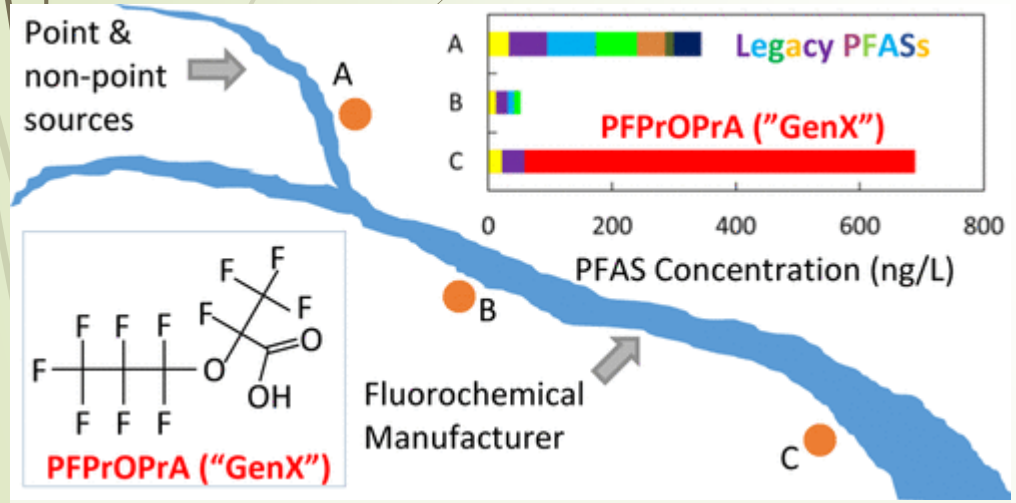
PFAS are widespread and poorly understood



PFAS contamination sites, from EWG 8/17/23

- Per- and polyfluoroalkylated substances are a class containing over 8,000 chemicals.
- Only a small number of PFAS have been studied; for most there is little or no toxicity data.
- Due to their widespread use and stability, PFAS are ubiquitous environmental contaminants.
- Even PFAS which have been phased out of use continue to be contaminants of concern due to their persistence in the environment and in organisms.

PFAS in North Carolina



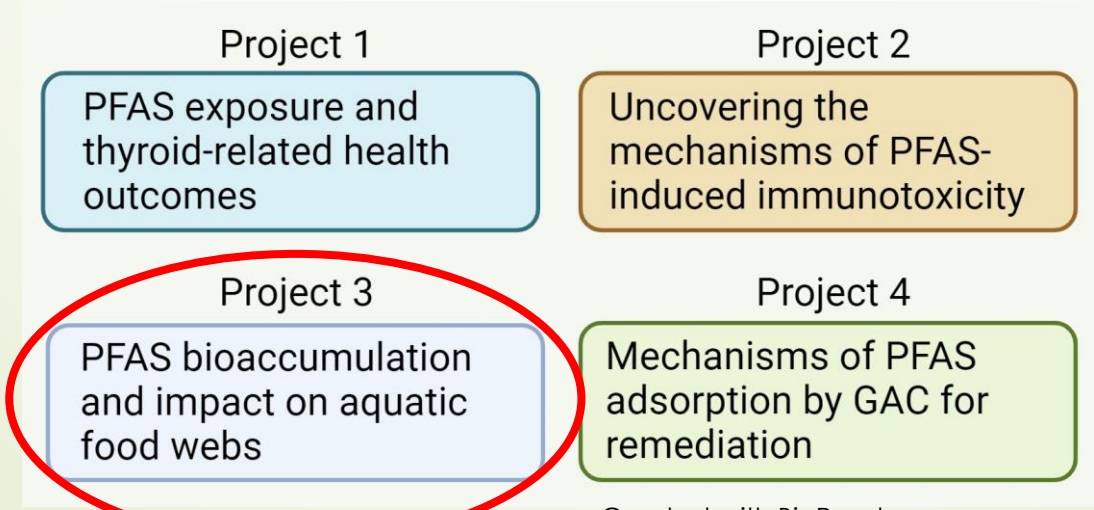
PFAS sampling sites on the Cape Fear River. Taken from Sun et al. 2016.

- In 2016, a number of PFAS were detected at numerous sites on the Cape Fear River, including high levels of the novel PFAS compound, GenX.
- The Cape Fear River watershed provides drinking water for over 1 million people in North Carolina. The discovery of a relatively unstudied contaminant there led to significant public concern.
- This discovery has led to an explosion of PFAS research in North Carolina as well as increased restrictions on emissions from manufacturing plants.

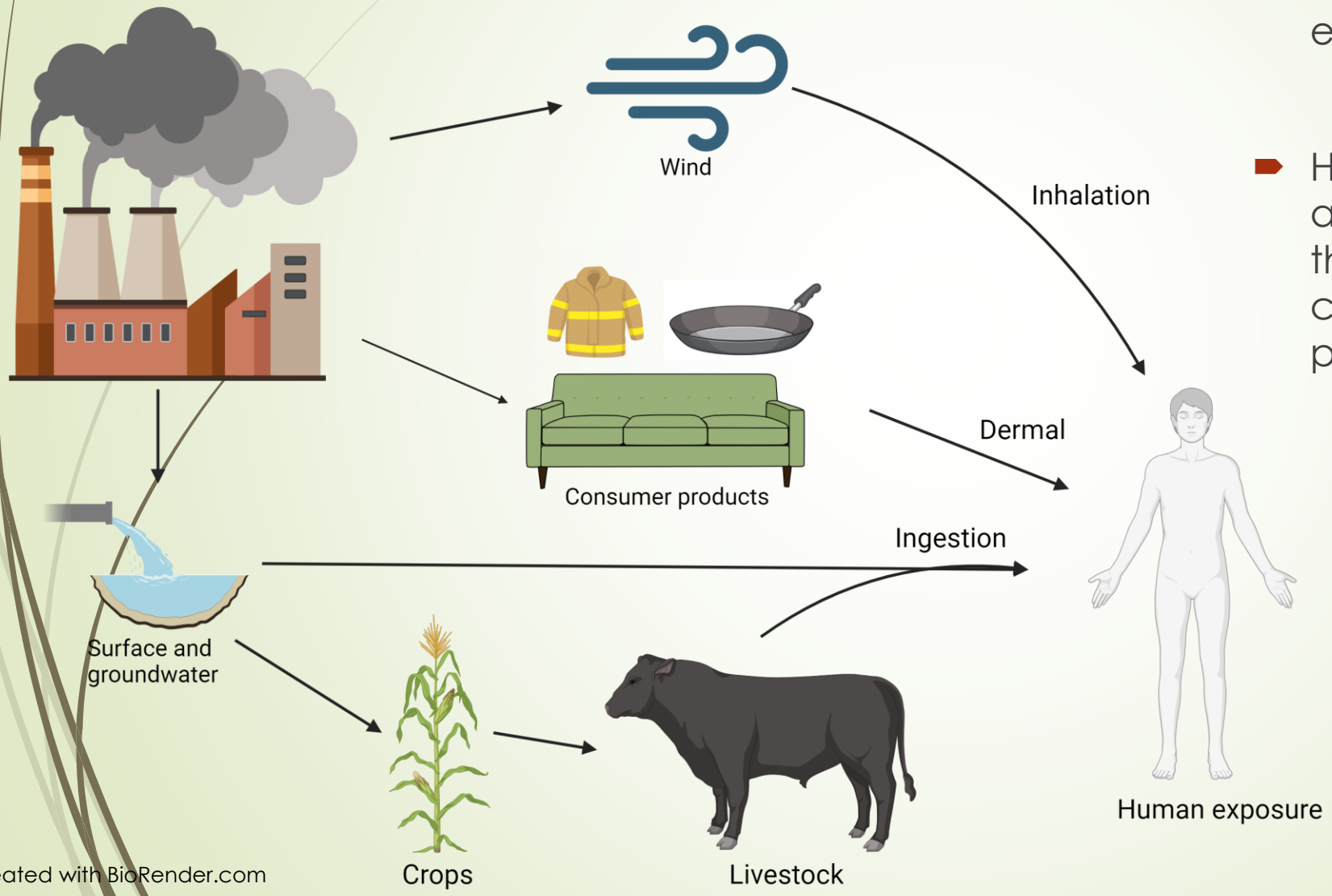
Center for Environmental and Health Effects of PFAS

- Established as part of the Superfund Research Program at NC State and ECU to address concerns related to the presence of PFAS in the Cape Fear River.

- The Center contains a number of projects focused on studying exposure, toxicity, bioaccumulation, and remediation of PFAS in North Carolina. These projects focus on both "legacy" PFAS compounds and novel PFAS such as GenX.



Exposure routes



- Water contamination has been the greatest focus of studies on exposure and remediation.
- However, the widespread use and persistence of PFAS means there are many possible points of contact with PFAS for exposed populations.

Dietary exposure and bioconcentration

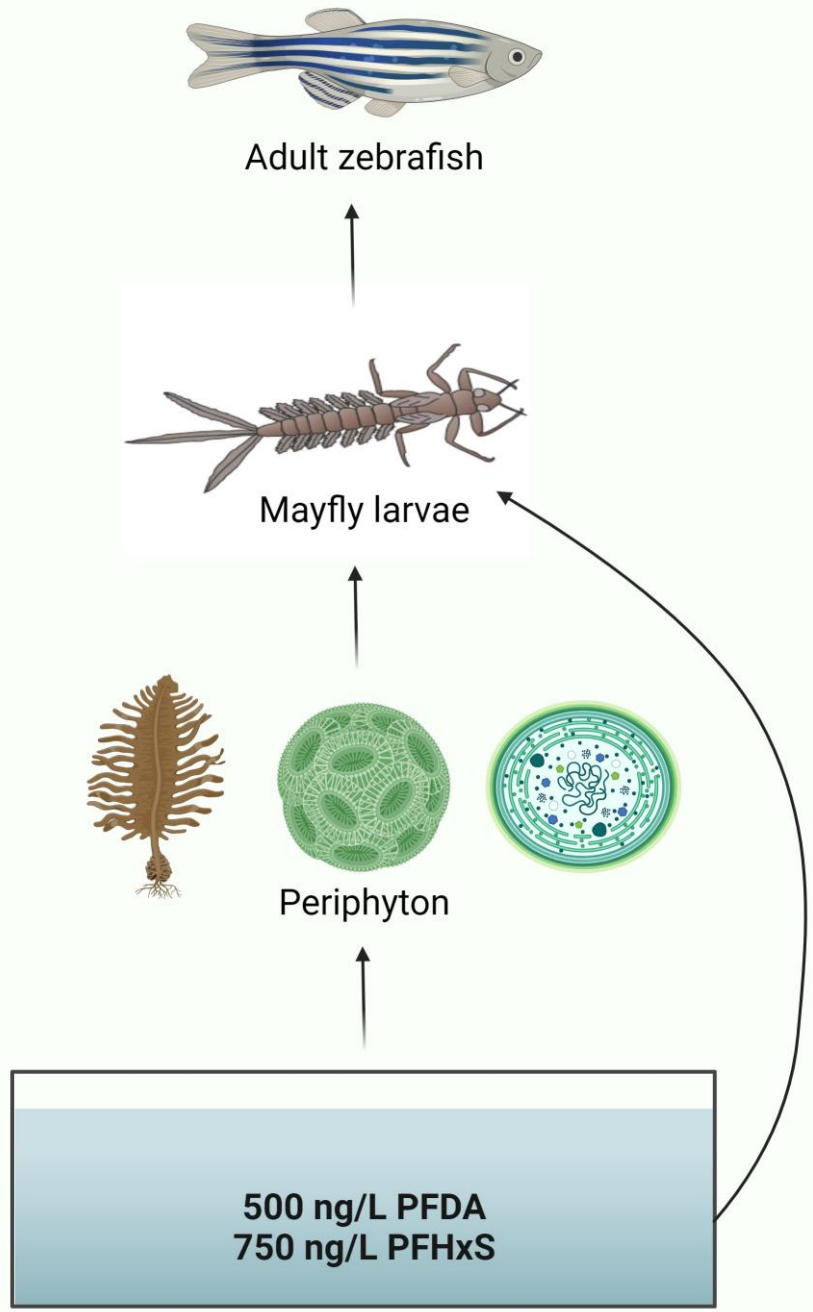
- PFAS are readily taken up from water and soil by crops and food animals.
- PFAS have been found at levels above environmental concentrations in the tissues of many animals, both aquatic and terrestrial.
- The uptake of PFAS through food has been demonstrated with numerous chemicals; long-chain PFAS with sulfonic acid head groups are especially bioaccumulative.
- PFAS tissue concentrations and elimination rates vary highly between different species even within the same environment, making comparison difficult.

Aquatic food web bioaccumulation

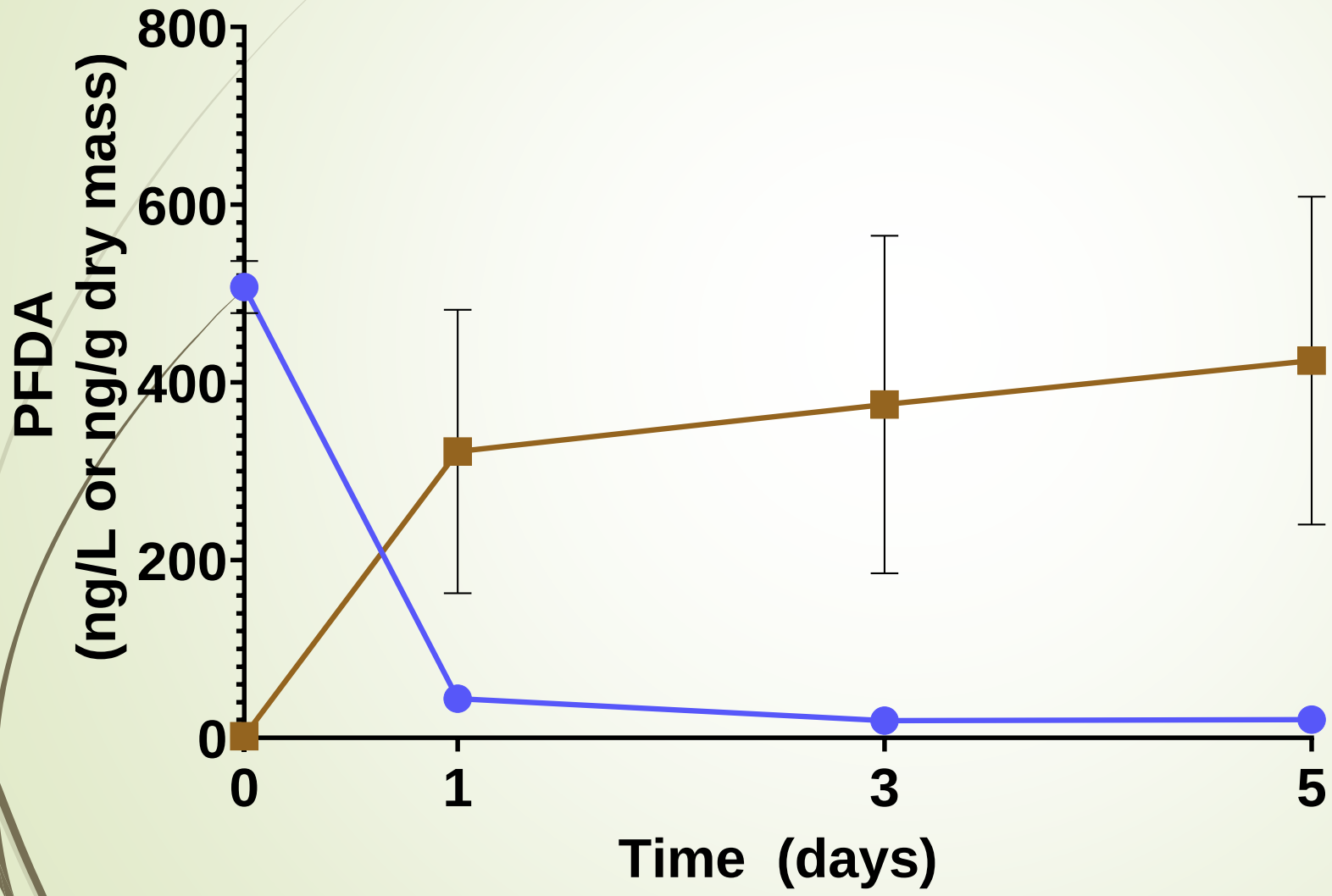
- Fish are a major food source for many communities around the world. Low-income areas near contaminated sites are particularly vulnerable, as subsistence fishing is often used to supplement other food sources.
- The biomagnification of pollutants is always a concern in aquatic food webs, as fish are exposed both aqueously and through diet. Fish at high trophic levels often contain high levels of contaminants such as mercury, PCBs, and dioxins.
- Aquatic food webs are directly impacted by contamination of the Cape Fear River, and it is essential that we understand the fate of PFAS as they move up trophic levels.

Experimental setup

- 5-day time course with periphyton in contaminated water.
- After the 5th day, larval mayflies were added and allowed to feed until nearing maturity, roughly 21 days.
- Fish were fed a single meal of mayflies. Half of the fish were collected immediately after feeding, while the other half were given 24 hours to clear the gut of any remaining food before collection.

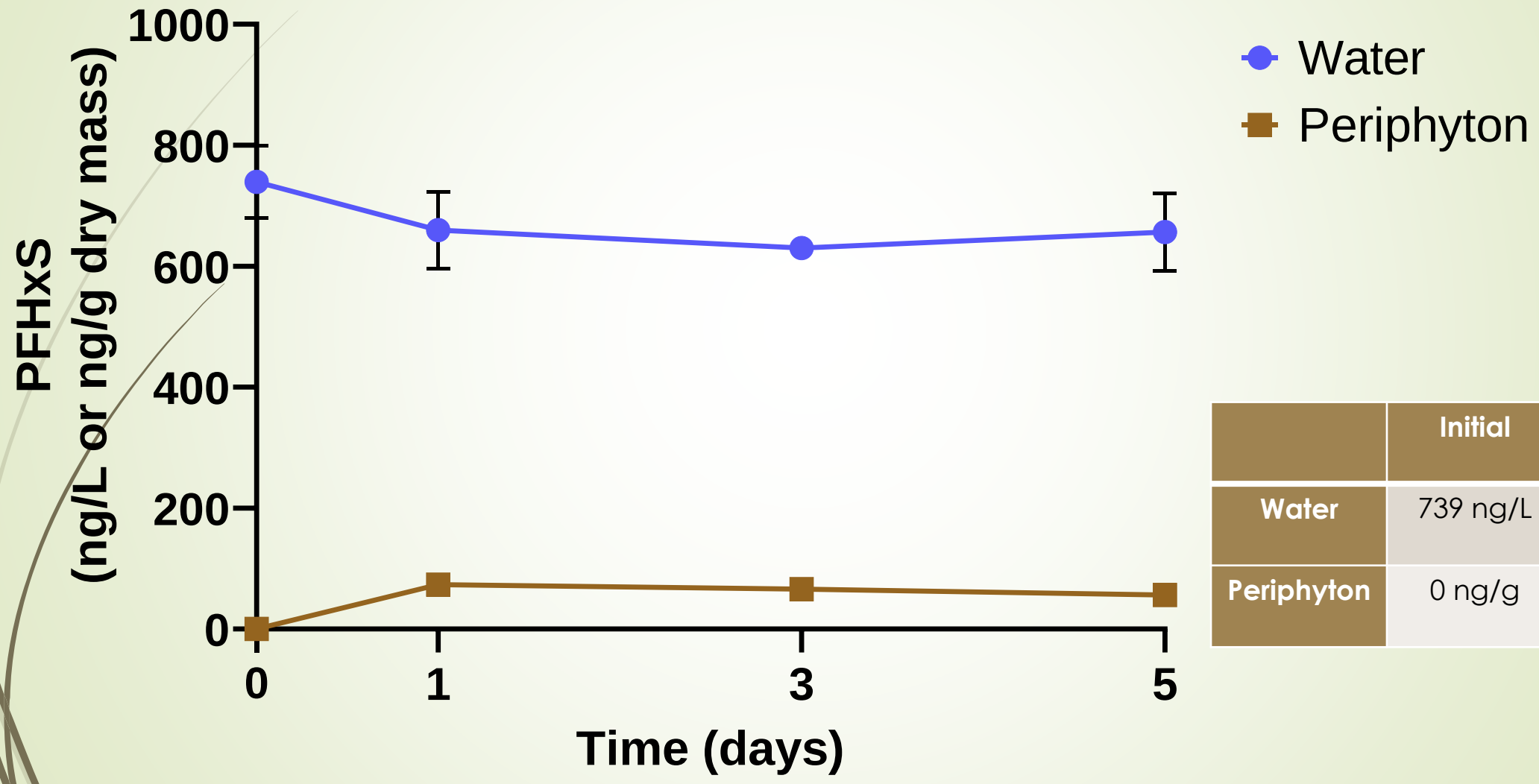


PFDA concentrations over 5-day exposure



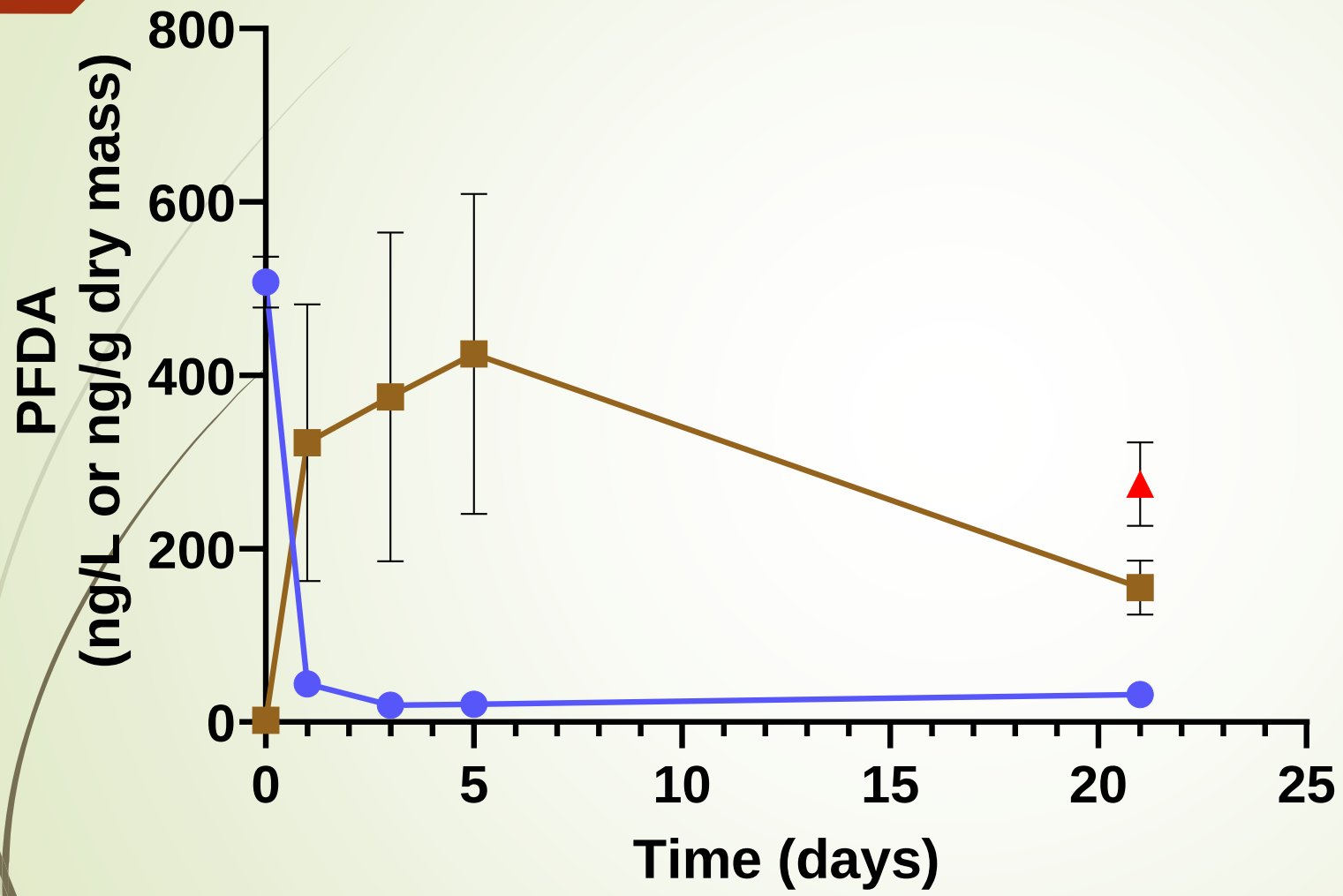
	Initial	Final
Water	507 ng/L	20.5 ng/L
Periphyton	2 ng/g	425 ng/g

PFHxS concentrations over 5-day exposure



	Initial	Final
Water	739 ng/L	656 ng/L
Periphyton	0 ng/g	56 ng/g

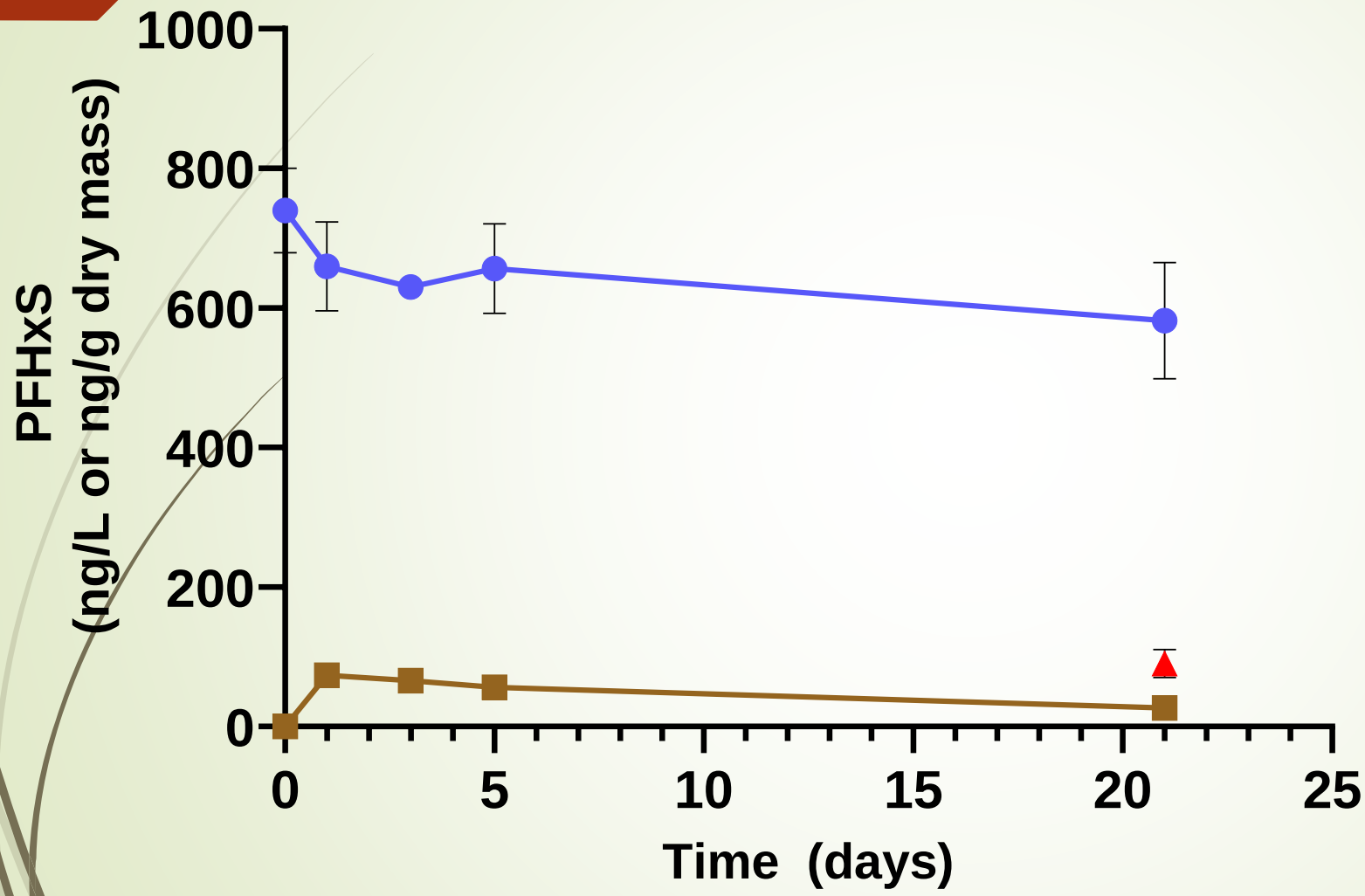
PFDA concentrations over 21-day exposure



	5 days	Final
Water	21 ng/L	32 ng/L
Periphyton	425 ng/L	155 ng/L
Mayflies	--	274 ng/g

Trophic transfer factor: 1.77

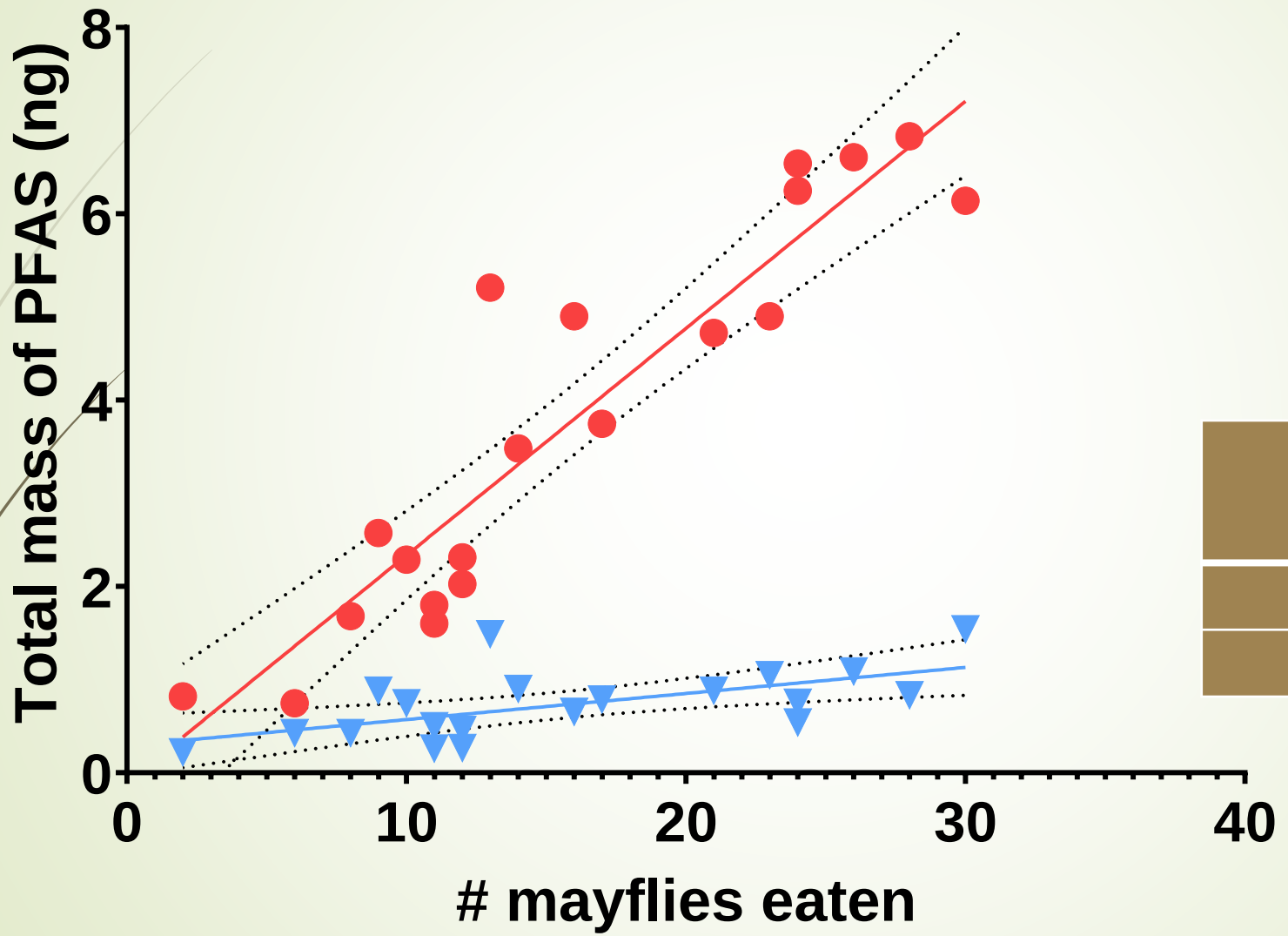
PFHxS concentrations over 21-day exposure



	5 days	Final
Water	656 ng/L	582 ng/L
Periphyton	56 ng/g	23 ng/g
Mayflies	--	90 ng/g

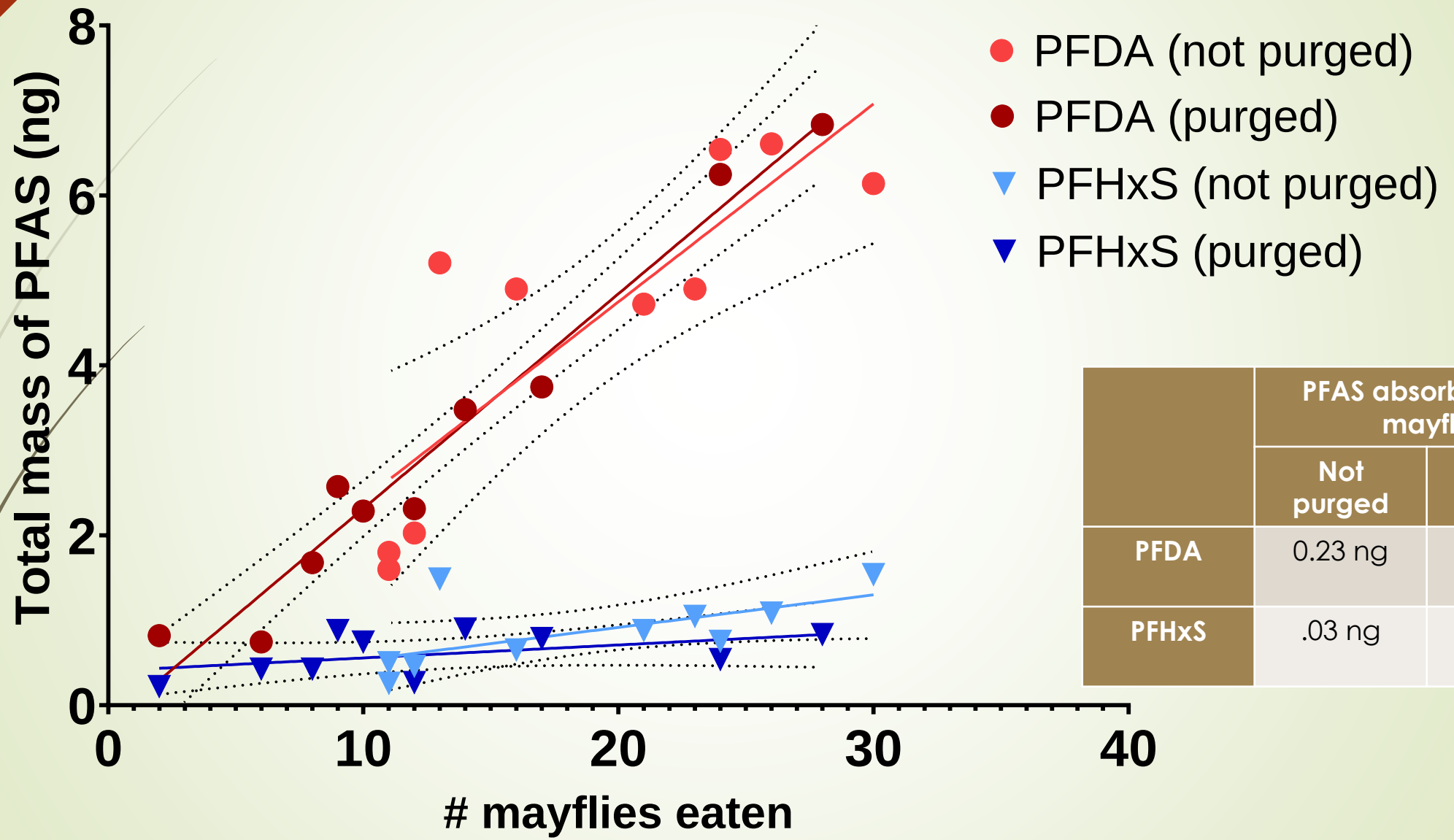
Trophic Transfer Factor: 3.38

Dietary PFAS uptake in adult zebrafish



	PFAS absorbed per mayfly
PFDA	0.24 ng
PFHxS	0.03 ng

Ingestion uptake of PFAS in adult zebrafish



	PFAS absorbed per mayfly	
	Not purged	Purged
PFDA	0.23 ng	0.25 ng
PFHxS	.03 ng	.02 ng

Future directions

- Further trophic transfer experiments are currently underway, testing both legacy and novel PFAS of concern in the region.
- We are performing chronic exposure studies in zebrafish using PFAS mixtures at concentrations similar to those detected in the Cape Fear River.
- Livers are being collected from exposed fish and used for whole proteome analysis to evaluate effects of chronic low-dose exposure on the liver proteome.
- Sections will be collected from remaining exposed fish and analyzed with IR-MALDESI to determine partitioning of various PFAS within the zebrafish.

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Questions?